Geophysical Research Abstracts
Vol. 20, EGU2018-696, 2018
EGU General Assembly 2018

Water ages in the critical zone of northern environments: Relation between storage and travel times of transpiration and recharge fluxes

Matthias Sprenger (1), Doerthe Tetzlaff (1,2,3), and Chris Soulsby (1)

(1) University of Aberdeen, Northern Rivers Institute, United Kingdom (matthias.sprenger@abdn.ac.uk), (2) IGB Leibniz Institute of Freshwater Ecology and Inland Fisheries, (3) Humboldt University Berlin

As the northern environments undergo intense changes due to warming climatic conditions and altered land use practices, there is a need for an improved understanding of the impact of atmospheric forcing and vegetation on water storage dynamics in the critical zone. We therefore assess the travel times of recharge and transpiration fluxes in four landscape units of podzol soils in the northern latitudes: two sites in the Bruntland Burn long-term experimental catchment (Scottish Highlands) were vegetated either with Scots pine (Pinus sylvestris) or Ericacae (Calluna vulgaris), one site in Dorset, Canada was covered with White pine (Pinus strobus), and one site in Krycklan, Sweden dominated by Scots pine (Pinus sylvestris).

We simulated the forward travel times by tracking individual precipitation and snowmelt events through the critical zone using the SWIS (Soil Water Isotope Simulator) model. A previous study showed that the SWIS model could simulate the hydrometric and isotopic dynamics in the upper 50 cm of the studied soils.

The resulting median travel times of soil waters percolating through the 50 cm depth plane ranged from few days to >200 days at Bruntland Burn and Dorset and >300 days at the Krycklan site. These time-variant travel times of the recharge flux showed for all sites an exponential relationship to the water storage in the soil. The lower the water volume in the considered soil volume, the more likely are longer travel times. The shortest travel times of the recharge occurred accordingly in winter and early spring when the storage was highest and evapotranspiration was lowest. Our findings on the pedon scale therefore indicate similar inverse storage effects as reported for water ages of discharge at the catchment scale. These general patterns are blurred in years of intense snow accumulation and high snowmelt volumes in spring. As shown for the Krycklan site, the travel time of recharging soil waters in such years was highly dependent on the timing of the snow melt and most water was flushed during the melt period.

The travel times of the transpiration ranged between few days and about 200 days depending on the time of infiltration of the traced precipitation or snowmelt. Water that infiltrated in late autumn stayed on average about 200 days in the soil before it was transpired in the following growing season. Thus, the dynamics of the transpiration water ages was mainly driven by the onset of the vegetation period.

Our findings provide new insights into the mixing and transport processes of soil water in the upper layer of the critical zone, which is relevant for hydrological modeling at the plot and catchment scales as the common assumption of a well-mixed system in the subsurface does not hold for the transpiration. Additionally, the transpiration ages show that water in the plant xylem can have relatively old ages depending on the year, which is relevant for ecohydrological studies inferring root water uptake depths using stable isotopes.